

U.S. Application No.

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PCT/JP00/03333

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**TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US)  
CONCERNING A FILING UNDER 35 USC 371**

International Application No.: PCT/JP00/03333  
International Filing Date: May 24, 2000  
Priority Date Claimed: May 24, 1999  
Title of Invention: ELECTROMAGNETIC WAVE SHIELDING KNITTED MATERIAL AND  
ELECTROMAGNETIC WAVE SHIELDING GARMENT  
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Katsuhiro Hori, Kenzo Ishikawa, Takahiro Yamazaki and Toshiyuki Shimizu

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. (X) This is a **FIRST** submission of items concerning a filing under 35 USC 371.
2. (X) This express request to begin national examination procedures (35 USC 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 USC 371(b) and PCT Articles 22 and 39(1).
3. (X) A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
4. (X) A copy of the International Application as filed (35 USC 371(c)(2))
  - a) () is transmitted herewith (required only if not transmitted by the International Bureau).
  - b) () has been transmitted by the International Bureau.
  - c) (X) a copy of Form PCT/1B/308 is enclosed.
  - d) () is not required, as the application was filed in the United States Receiving Office (RO/US).
5. (X) A translation of the International Application into English (35 USC 371(c)(2)).
6. (X) Amendments to the claims of the International Application under PCT Article 19 (35 USC 371(c)(3))
  - a) () are transmitted herewith (required only if not transmitted by the International Bureau).
  - b) () have been transmitted by the International Bureau.
  - c) () have not been made; however, the time limit for making such amendments has NOT expired.
  - d) (X) have not been made and will not be made.
7. (X) **SIGNED** Declaration and Power of Attorney of the inventors (35 USC 371(c)(4)).
8. (X) A translation of the annexes, such as any amendments made under PCT Article 34, to the International Preliminary Examination Report under PCT Article 36 (35 USC 371(c)(5)).
9. (X) An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
10. (X) Drawing in six (6) pages.

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11. (X) International Search Report.
12. (X) International Application as published-face sheet only.
13. (X) Verification of a Translation.
14. (X) A return prepaid postcard.
15. (X) The following fees are submitted:

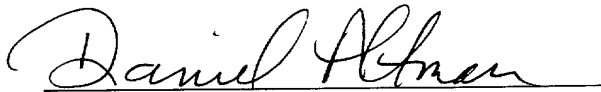
**FEES**

<b>BASIC FEE</b>				\$890
<b>CLAIMS</b>	<b>NUMBER FILED</b>	<b>NUMBER EXTRA</b>	<b>RATE</b>	
Total Claims	17 - 20 =	0 ×	\$18	\$0
Independent Claims	2 - 3 =	0 ×	\$84	\$0
<b>TOTAL OF ABOVE CALCULATIONS</b>				\$890
<b>TOTAL FEES ENCLOSED</b>				\$890

16. (X) A check in the amount of \$890.00 to cover the above fees is enclosed.
17. (X) Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). \$40 per property.
18. (X) The Commissioner is hereby authorized to charge only those additional fees which may be required, now or in the future, to avoid abandonment of the application, or credit any overpayment to Deposit Account No. 11-1410.

**NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.**

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## DESCRIPTION

ELECTROMAGNETIC WAVE SHIELDING KNITTED MATERIAL AND  
ELECTROMAGNETIC WAVE SHIELDING GARMENT

5

TECHNICAL FIELD

The present invention relates to an electromagnetic wave shielding knitted material and an electromagnetic wave shielding garment, which protect the human body from the influence of electromagnetic waves leaked from cellular telephones, microwave ovens, CRTs of televisions and personal computers or other electronic equipment that generates electromagnetic waves, and electromagnetic fields radiated from antennas of cellular telephones, radio equipment and like equipment placed in the vicinity of the human body. The electromagnetic wave shielding knitted material and electromagnetic wave shielding garment according to the present invention not only protect the human body from the influence of electromagnetic waves, but also effectively prevent electromagnetic waves from causing malfunction of medical devices implanted in the body, such as pacemakers.

BACKGROUND OF THE INVENTION

As a conventional measure to prevent damages by electromagnetic waves emitted from an electromagnetic source, a metal net or like electromagnetic wave blocking

layer is wrapped around the electromagnetic source to prevent leakage of electromagnetic waves. However, with the recent development of electronic equipment, electromagnetic sources greatly increase in number and become more and more miniaturized. Accordingly, attempts have been made to provide an electromagnetic source with an electromagnetic wave shielding net (layer) to prevent leakage of electromagnetic waves. For this purpose, Japanese Unexamined Patent Publication No. 1998-168702, Japanese Utility Model No. 3010147, Japanese Unexamined Patent Publication No. 1996-176962 and Japanese Unexamined Patent Publication No. 1998-292252 disclose knitted or woven electromagnetic wave shielding nets (knitted or woven fabrics) made of lightweight, flexible conductive fibers developed for use as an electromagnetic wave blocking film or as an equipment's built-in electromagnetic wave shielding net.

However, the disclosed techniques are not capable of completely shielding electromagnetic wave sources. Moreover, electromagnetic wave emission is essential in some equipment, such as radio equipment. Therefore, shielding measures only on electromagnetic wave sources are clearly insufficient.

Thus, there is a necessity for an electromagnetic wave shielding measure with a garment for

the human body. Electromagnetic wave shielding garments should have comfortable wearability as well as high electromagnetic wave attenuation efficiency. Some electromagnetic wave shielding garments have been proposed which consist merely of conductive fibers, but these garments are poor in softness, drapability, bulkiness, compression characteristics and like characteristics that determine so-called "hand". Thus, these garments are not only unsatisfactory in basic requirements such as sweat absorbency, but also liable to cause skin disorders (allergies) due to metals contained in conductive fibers. Accordingly, a measures to solve these problems has been strongly desired.

Japanese Unexamined Patent Publication No. 1998-77507 proposes a garment comprising a natural or chemical fiber knitted or woven together with a conductive fiber.

Further, Japanese Unexamined Patent Publication No. 1999-50352 proposes a fabric having both electromagnetic wave shielding capability and metal allergy resistance, the fabric being obtained by covering a conductive fiber as stuffing thread with a nonconductive fiber so that the conductive fiber is out of direct contact with the skin.

However, although the garment disclosed in Japanese Unexamined Patent Publication No. 1998-77507 is

reduced in the amount of direct contact of the conductive fiber with the skin, the conductive fiber still partially comes into direct contact with the skin. Accordingly, the garment is unsatisfactory in view of its unpleasant

5 wearing feeling and metal allergy resistance. On the other hand, the fabric disclosed in Japanese Unexamined Patent Publication No. 1999-50352 is free from the above problems since the conductive fiber used therein does not come into direct contact with the skin. However, there is  
10 a further demand for decreasing the amount of conductive fiber to be used for reducing the cost, since conductive fibers are generally extremely expensive.

Japanese Examined Utility Model Publication No. 1992-54165 discloses an undergarment which is always  
15 wearable, obtained by sewing a knitted or woven fabric laminate comprising a knitted or woven fabric made of a conductive fiber and a knitted or woven fabric made of a highly hygroscopic fiber for normal clothes, in such a manner that the highly hygroscopic fabric comes inside the  
20 undergarment. However, the publication nowhere discloses specific means for imparting an effective electromagnetic wave shielding capability to the knitted or woven fabrics.

Conventionally, in specifications of  
electromagnetic wave shielding garments, electromagnetic  
25 shielding properties of an electromagnetic wave shielding

garment comprising a conductive fiber yarn were measured using a material piece of the garment, by widely known KEC method, Advantest method or like method using an apparatus for measuring and evaluating electromagnetic wave  
5 shielding properties, in order to prevent the influence of electromagnetic waves on the human body and on medical equipment implanted in the human body.

However, even if the material piece has a desired electromagnetic wave shielding capability, the  
10 garment sometimes does not have the desired electromagnetic wave shielding capability, due to diffraction, infiltration, etc. of electromagnetic waves, depending on the garment shape.

The present invention has been accomplished in  
15 view of the above situation. An object of the present invention is to provide a material for clothes which gives no unpleasant feeling when being put on, causes no skin disorder due to metal allergy, and contains less amount of conductive fiber while maintaining electromagnetic wave  
20 shielding capability, so as to achieve reduction in cost.

A further object of the present invention is to provide an electromagnetic shielding garment free of influence of diffraction, infiltration, etc. of electromagnetic waves, the garment being obtainable by  
25 measuring electromagnetic shielding capability as a

garment, and designing and making a garment shape to achieve a desired electromagnetic wave shielding capability.

BRIEF DESCRIPTION OF THE DRAWINGS

5           Fig. 1 is a graph showing the relation between cotton count and shielding capability in Example 1.

          Fig. 2 is a graph showing the relation between cotton count and G-soft in Example 1.

10           Fig. 3 is a graph showing the relation between cotton count and shielding capability in Example 2.

          Fig. 4 is a graph showing the relation between cotton count and G-soft in Example 2.

15           Fig. 5 is a front view of an embodiment of the electromagnetic wave shielding knitted material of the present invention.

          Fig. 6 is a graph showing the relation between electromagnetic wave shielding capability and cost.

20           Fig. 7 is a diagram of a measurement system for an apparatus for measuring and evaluating electromagnetic wave shielding properties as a garment.

          Fig. 8 shows the result of electromagnetic field distribution analysis of the short-sleeved, round-necked undershirt model obtained in Example 5.

25           Fig. 9 shows the result of electromagnetic field distribution analysis of the short-sleeved, V-necked



undershirt model obtained in Example 6.

Fig. 10 shows the result of electromagnetic field distribution analysis of the collard shirt type garment model obtained in Comparative Example 3.

5 Fig. 11 shows the result of electromagnetic field distribution analysis of the vest type garment model obtained in Comparative Example 4.

Fig. 12 shows the result of electromagnetic field distribution analysis of the dummy of the human body  
10 without an electromagnetic wave shielding garment in Comparative Example 5.

#### DISCLOSURE OF THE INVENTION

The present invention provides the following electromagnetic wave shielding knitted materials and  
15 electromagnetic wave shielding garments.

1. A reversible electromagnetic wave shielding knitted material comprising a conductive fiber yarn as a surface side and a natural fiber yarn as a back side.

2. A material according to item 1, which  
20 comprises a plain knitted structure or rib knitted structure obtained by plating the conductive fiber yarn and the natural fiber yarn in all the courses of the knitted material.

3. A material according to item 1, wherein the  
25 conductive fiber yarn is a multifilament in which each

filament comprises a nylon fiber, a polyester fiber, an acrylic fiber, a polypropylene fiber or like synthetic fiber having a denier (d) of about 2 to about 8, and a metal component applied to a surface of the synthetic  
5 fiber by sputtering, vacuum deposition, electroless plating or like method.

4. A material according to item 1, wherein the conductive fiber yarn is a fiber of polyacetylene or like conductive resin, or a fine wire of gold, silver, copper,  
10 stainless steel or like metal.

5. A material according to item 1, wherein the natural fiber yarn comprises a natural fiber, a natural fiber/rayon fiber mixed spun yarn, or a natural fiber/synthetic fiber mixed spun yarn.

15 6. A material according to item 1, wherein the conductive fiber yarn is a silver-plated nylon yarn having a denier (d) of about 70 to about 210, and the natural fiber yarn is a cotton yarn having a count of 30 to 150, the material having a KES hand value (G-soft) of at least  
20 6 and an electromagnetic wave shielding capability of at least 20 dB.

7. A material according to item 1, which comprises, as the surface side, the conductive fiber yarn and an elastic fiber yarn interknitted with each other.

25 8. A material according to item 7, wherein the

elastic fiber yarn is a single-covered yarn or a double-covered yarn comprising a polyurethane thread as a stuffing thread covered with a nylon thread.

9. A material according to item 7, wherein the  
5 elastic fiber yarn has a denier (d) of about 10 to about 200.

10. A material according to item 7, wherein the proportion of the elastic fiber yarn is greater than 0 but not greater than  $\frac{2}{3}$  of the total amount of the conductive  
10 fiber yarn and the elastic fiber yarn interknitted with each other.

11. A material according to item 1, which is used as an undergarment.

12. An electromagnetic wave shielding garment  
15 obtainable by: measuring electromagnetic wave shielding capability as a garment using an apparatus for measuring and evaluating electromagnetic wave shielding capability comprising a measurement system in the shape of the upper part of the human body for measuring electromagnetic wave  
20 shielding capability as a garment in the state of being worn by the human body; designing a garment shape to obtain a desired electromagnetic wave shielding capability; and making a garment of the designed shape.

13. An electromagnetic wave shielding garment  
25 according to item 12, wherein the apparatus for measuring

and evaluating electromagnetic wave shielding capability comprises: a signal transmitter for emitting a high-frequency signal; a transmission antenna connected to the high-frequency signal transmitter for radiating a high-frequency electromagnetic field into a free space; a dummy which is similar to the human body in shape and electric constants including dielectric constant and magnetic permeability; a receiving antenna provided at a predetermined position within the dummy for receiving the high-frequency electromagnetic field, the receiving antenna being equivalent in impedance to the human body and similar in shape to a lead wire of a device surgically implantable in the human body; and a signal receiver connected to the receiving antenna for receiving the high-frequency signal.

14. A garment according to item 12, which has an electromagnetic wave shielding capability as a garment of at least 15 dB when the distance between the transmission antenna and the surface of the dummy is 5 cm, at least 18 dB when the distance is 10 cm, and at least 20 dB when the distance is 20 cm, relative to the amount of electromagnetic waves received by the dummy without the garment.

15. An electromagnetic wave shielding garment according to item 12, which has such a shape that forms no

gap when worn.

16. An electromagnetic wave shielding garment according to item 15, wherein the shape that forms no gap is an undergarment or a T-shirt.

5 17. An electromagnetic wave shielding garment according to item 12, which prevents electromagnetic waves from causing cardiac pacemaker malfunction.

Since the knitted material of the present invention is used as a garment (in particular, an  
10 undergarment), the material has a reversible structure in which the side close to the skin comprises a natural fiber yarn. To obtain such a structure, a conductive fiber and a clothing fiber are fed to a plain knitting machine or a rib knitting machine in such a manner that the conductive  
15 fiber is covered with the clothing fiber. For example, plating of a conductive fiber yarn and a natural fiber yarn is carried out in all the courses so that the natural fiber yarn comes to the side close to the skin.

Examples of conductive fiber yarns for use in  
20 the invention include yarns made of fibers of polyacetylene or like conductive resin; yarns obtained by applying polyacetylene or like conductive resin to a synthetic fiber such as nylon, polyester, acrylic or polypropylene; yarns obtained by applying gold, silver,  
25 copper, nickel or like metal component by vacuum

deposition, sputtering, electroless plating or like method; and fine wires of stainless steel, gold, silver, copper or like metal. Particularly preferred are yarns obtained by electrolessly plating a synthetic fiber with  
5 silver.

Specific examples of conductive fiber yarns include X-Static (tradename of Sauquit) comprising a nylon multifilament plated with silver.

Preferably, each filament of the conductive  
10 fiber yarn has a denier (d) of about 2 to about 8, and the conductive fiber yarn has a denier (d) of about 70 to about 210.

Examples of natural fiber yarns include yarns of cotton, silk, hemp or the like; and yarns of rayon, Lyocel,  
15 Tencel or like regenerated fiber; yarns of acetate, diacetate or like semi-synthetic fiber; and yarns of acrylate, modified nylon or like hygroscopic synthetic fiber with satisfactory comfortableness as an undergarment. The natural yarn for use in the invention is not limited  
20 to the above examples, and include rayon staple fiber spun yarns, natural fiber and rayon fiber mixed spun yarns, and natural fiber and synthetic fiber mixed spun yarns. Using any of these yarns, a knitted garment (in particular, an undergarment) which can prevent the body from the  
25 electromagnetic wave damages and have good wearing feeling

and hand.

The electromagnetic wave shielding knitted material of the invention has higher hand (has a higher G-SOFT value) when using a natural fiber yarn with a higher fineness. On the other hand, the material has a higher electromagnetic wave shielding capability when using a conductive fiber yarn with a lower fineness. However, the fineness of the two types of yarns should be well-balanced, since a great difference in fineness results in unstable knitting operation.

Considering the hand, electromagnetic wave shielding capability and balance in fineness, the natural fiber yarn, when made of cotton, has a cotton count of 30 to 150, preferably 30 to 90, more preferably 40 to 70. The conductive fiber yarn, when being a silver-plated nylon yarn, has a denier (d) of 70 to 210, preferably 70 to 150, more preferably 80 to 120.

Since conductive fiber yarns are generally very expensive, the conductive fiber yarn side of the material of the invention may further comprises an elastic fiber yarn interknitted with the conductive fiber yarn, in order to decrease the amount of the conductive fiber yarn and thereby reduce the cost. A preferred elastic fiber yarn is a single-covered or double-covered yarn comprising a polyurethane thread as a stuffing thread covered with a

nylon thread. However, any yarns having properties equivalent to the single- or double-covered yarn are usable.

As to the fineness of the elastic fiber yarn, an  
5 elastic fiber yarn with a denier (d) less than about 10 is not preferable, since use of such an elastic fiber yarn forms large spaces between the conductive fiber yarns due to insufficient elasticity, resulting in a lowered  
10 electromagnetic wave shielding capability. On the other hand, an elastic fiber yarn with a denier (d) of greater than about 200 is also undesirable, since the elastic fiber yarn is too thick and forms large spaces between the conductive fiber yarns, resulting in a lowered  
15 electromagnetic wave shielding capability. Therefore, the elastic fiber yarn preferably has a denier (d) of about 10 to about 200, more preferably about 70 to about 200.

When interknitting the conductive fiber yarn and the elastic fiber yarn, the proportion of the elastic fiber yarn is preferably greater than 0 but not greater  
20 than  $\frac{2}{3}$ , more preferably greater than  $\frac{1}{3}$  but not greater than  $\frac{1}{2}$ .

The electromagnetic wave shielding knitted material of the invention is suitable for shirts, briefs, knit trunks and other undergarments, T-shirts and like  
25 clothes.



Fig. 5 shows an embodiment of the electromagnetic wave shielding knitted material of the present invention. In Fig. 5, 1 and 2 indicate a conductive fiber yarn and an elastic fiber yarn, respectively. These yarns are interknitted at a ratio of 1:1 (the proportion of the elastic fiber yarn being 1/2) to form a front side of the knitted material. 3 indicates a natural fiber yarn which is knitted to form a back side (the side close to the skin) of the knitted material.

Thus, the knitted material of this embodiment is knitted as a reversible plain knitted fabric. However, the knitted material of the invention is not limited to the reversible plain knitted fabric, but may have any knit structure as long as it has a reversible form.

The electromagnetic wave shielding garment of the invention is designed using an apparatus for measuring and evaluating electromagnetic wave shielding capability comprising a measurement system in the shape of the upper part of the human body in order to maintain the state of a garment as worn on the human body. The apparatus comprises, for example: a signal transmitter for transmitting a high-frequency signal; a transmission antenna connected to the high-frequency signal transmitter for radiating a high-frequency electromagnetic field into a free space; a dummy having a shape and electric

constants (dielectric constant, magnetic permeability, etc.) approximately equal to the human body; a receiving antenna provided at a predetermined position within the dummy for receiving the high-frequency electromagnetic field, the receiving antenna being equivalent in impedance to the human body and a approximately similar in shape to a lead wire of a device surgically implantable in the human body; and a signal receiver connected to the receiving antenna for receiving the high-frequency signal.

10           Fig. 7 shows an embodiment of the measurement system of the apparatus for measuring and evaluating electromagnetic wave shielding capability used in the present invention. An electromagnetic wave shielding garment 1 is put on a dummy of the human body 2. High-  
15 frequency electric power with a predetermined frequency band is applied from the direction of a transmission antenna 3, and high frequency electric power that has passed through the shielding garment 1 is received by a receiving antenna 4 provided at a predetermined position  
20 within the dummy 2, thereby measuring the electromagnetic wave shielding capability of the shielding garment 1. A signal transmitter 5 is used to apply high-frequency electric power to the transmission antenna 3, and a signal receiver 6 is used to detect high-frequency electric power  
25 that has passed through the shielding garment 1 from the

receiving antenna 4. As the signal transmitter 5 and the signal receiver 6, a network analyzer or like means serving as both the transmitter and the receiver may be used to output high-frequency electric power with an automatically scanned frequency and detect high-frequency electric power. The dummy 2 is a container molded of FRP (specific dielectric constant 3) filled with a 0.5% NaCl solution which is widely used as a solution equivalent in dielectric constant and other electric constants to the living body. Although this embodiment employs an FRP-molded container and a 0.5% NaCl solution, it is also possible to employ a generally used phantom having a dielectric constant and magnetic permeability equivalent to those of the human body or like living body. In short, any dummy may be utilized as long as it has a shape and electric constants (such as dielectric constant and magnetic permeability) approximately equal to those of the human body and has a structure that permits setting of the receiving antenna 4 at a predetermined position within the dummy. The receiving antenna 4 is an imitation of a lead wire of a cardiac pacemaker, i.e., an implantable device in which the influence of antennas of cellular telephones, radio equipment or like equipment placed in the vicinity of the human body may cause serious trouble. The receiving antenna 4 comprises a coaxial cable and a load

resistor (500  $\Omega$ ) connected at the end of the coaxial cable to attain an impedance equivalent to that of the human body. The coaxial cable preferably has a shape similar to a lead wire of a cardiac pacemaker implanted within the human body. Although this embodiment employs a coaxial cable and a load resistor, it is of course possible to use a cardiac pacemaker lead wire as such. That is to say, any structure can be used as long as it is equivalent in impedance to the human body and similar in shape to a device implantable within the human body. In this embodiment, a cardiac pacemaker is assumed as the implantable to be protected from electromagnetic waves, but the apparatus of the invention can be applied to measure capability of shielding other types of implantable devices from electromagnetic waves, by properly constructing the receiving antenna 4.

With the apparatus of the invention, an electromagnetic wave shielding garment can be put on the dummy to measure capability of shielding electromagnetic waves propagated from a desired position, angle and distance. Using the apparatus, it is possible to design a garment shape to obtain a desired electromagnetic wave shielding capability without the influence of diffraction, infiltration, etc. of electromagnetic waves, and make a garment of the designed shape. The process for designing

the garment shape usually comprises: propagating electromagnetic waves from a desired position, angle and distance to measure the electromagnetic wave amount received by the dummy of the human body wearing the garment and the amount received by the dummy without the garment; and determining the material and shapes of the neck, sleeves, overlapping portion on the body of the electromagnetic wave shielding garment so that the garment has, under the same electromagnetic wave propagation conditions, an electromagnetic wave shielding capability of at least 10 dB, preferably at least 15 dB, more preferably at least 15 dB when the distance between the transmission antenna and the surface of the dummy is 5 cm, and at least 18 dB when the distance is 10 cm, and at least 20 dB when the distance is 20 cm.

The electromagnetic wave shielding garment of the invention is preferably made from a knitted fabric comprising a conductive fiber yarn as described above, a woven fabric, a nonwoven fabric, a mesh fabric and like fabrics having, as the fabric itself, excellent capability of shielding electromagnetic fields in the vicinity. More preferably, the electromagnetic wave shielding garment is made from the electromagnetic wave shielding knitted material of the invention.

The electromagnetic wave shielding garment of

the invention can be obtained by cutting and sewing a fabric having, as the fabric itself, excellent capability of shielding electromagnetic fields in the vicinity as described above. When making the garment, parts

5 constituting the garment are preferably sewn so that the conductive fiber yarn-containing surfaces of the parts are brought into contact with each other to provide conduction. More preferably, the conductive fiber yarn-containing surfaces of the parts are brought into contact with each

10 other and then sewn together with conductive thread. As to the garment shape, a garment having a front button closure or like overlapping portion on the body, such as a collared shirt, is not desirable since, when wearing the garment, gaps are formed at the overlapping portion and

15 allow electromagnetic waves to infiltrate. Also undesirable is a garment in which a conductive material covers only part of the human body, such as an apron for covering only the front side of the human body, since electromagnetic waves diffuse inside the garment around

20 the edge of the conductive material.

Thus, the electromagnetic wave shielding garment of the invention has a shape that can achieve a desired electromagnetic wave shielding capability without the influence of diffraction, infiltration, etc. of

25 electromagnetic waves, the shape being obtained by

measurement with an apparatus for measuring and evaluating electromagnetic wave shielding capability as a garment.

Preferable is a garment for the upper part of the body, in which the whole surface contains a conductive material,

5 and which has no overlapping portion, or has an overlapping portion that does not impair the conductivity nor does form gaps when the wearing the garment.

More preferred is a short-sleeved or long-sleeved undergarment or T-shirt, or a collared shirt  
10 having, at the overlapping portion on the body, a fastener made only of conductive materials. Most preferable is a round-necked or high-necked garment with long or short sleeves with fastened cuffs, since such a garment can prevent infiltration of electromagnetic waves from the  
15 cuffs and neck openings. The material and structure of the electromagnetic wave shielding garment of the invention is not limited to those described above.

#### BEST MODE FOR CARRYING OUT THE INVENTION

20 The following examples are provided to illustrate the present invention in further detail, and are not to limit the scope of the claims of the invention. In the Examples, materials and garments are evaluated by the following methods:

25 (1) Electromagnetic wave shielding capability as a

material (KEC method)

A material (20 cm x 20 cm) to be tested was held between a transmission antenna and a receiving antenna installed within a short distance of each other in a shield box (MB8602B; a product of Anritsu).

Electromagnetic waves of different frequencies ranging from 100 MHz to 1 GHz were transmitted, and the attenuation at each frequency was measured using a

spectrum analyzer (TR4173; Advantest). The shielding capability was evaluated by the difference (dB) between the measurements with and without the material held between the antennas, at a frequency band for cellular telephones (800 MHz).

(2) Electromagnetic wave shielding capability as a garment

In an electric wave darkroom, the electromagnetic wave shielding capability as a garment was measured, using the measurement system shown in Fig. 7.

Specifically stated, high-frequency electric power (800 MHz) was transmitted from a signal transmitter 5 (R3551; Advantest) via a transmission antenna 3 (dipole antenna TR1722; Advantest) installed at a predetermined position, angle and distance, toward a dummy 2 (a human-shaped container molded of FRP with a specific dielectric constant of 3 and filled with a 0.5% NaCl solution widely known as a solution equivalent to the living body in



electric constants such as dielectric constant). The dummy 2 was provided, at a predetermined position therein, with a receiving antenna 4 (an antenna comprising a coaxial cable and a 500  $\Omega$  load resistor connected at the end of the coaxial cable to attain an impedance equivalent to that of the living body, the coaxial cable being similar in shape to a lead wire of a cardiac pacemaker implantable in the human body). The attenuation of transmitted electric power was measured with and without putting an electromagnetic wave shielding garment 1 on the dummy 2, using a signal receiver 6 (spectrum analyzer R3361A; Advantest). As to the position, angle and distance of the transmission antenna 3, the antenna 3 was placed in front of the dummy 2, at the same height as the receiving antenna 4, at such an angle that the element is in the horizontal position, and at a distance of 5 cm, 10 cm or 20 cm from the dummy 2. These conditions produced most significant differences in electromagnetic wave shielding capability as a garment. The shielding capability was evaluated by the difference (dB) between the measurements with and without the electromagnetic wave shielding garment on the dummy.

(3) Electromagnetic field distribution analysis by FDTD method

Using an FDTD analysis simulator (XFDTD 5.0 Bio-

Pro; REMCOM), a dummy having a 300 mm x 100 mm x 500 mm body with a conductivity of 1.43 and a specific dielectric constant of 53, a neck and arms was defined in a free space (600 mm x 400 mm x 700 mm) divided into 10 mm x 10 mm x 10 mm cubes. Then, a 800 MHz sine wave was radiated from a half-wavelength dipole antenna horizontally placed 50 mm ahead of the dummy, to determine magnetic field intensity distribution (Hz components, XZ section) about 10 ns after reaching a steady state at a depth of 15 mm from the body surface of the dummy (the depth at which a pacemaker is implanted). Models of the shielding garments shown in Table 2 were used as analysis models. The models had a conductivity of  $\sigma = 1 \times 10^5 \text{ S/m}$ , which is similar to the conductivity of the shielding garments, and were put on the dummy with a 5 mm gap between the model and the dummy. The evaluation was carried out based on the color of the chest portion in the analysis results (Figs. 8 to 12). The magnetic field intensities indicated by the colors is greater in the order of:

red>orange>yellow>green>blue. Thus, warm colors indicate a great amount of electromagnetic waves.

(4) G-soft evaluation test method:

This test was carried out according to "Standardization and Analysis of Evaluation of Hand" (second edition, Sueo Kawabata, Journal of the Textile

Machinery Society of Japan, July 10, 1980).

KES mechanical properties are defined as follows.

- 1: LT    Linearity of tension
- 2: WT    Tensile energy per unit area
- 5    3: RT    Tensile resilience
- 4: B    Bending rigidity per unit length
- 5: 2HB    Hysteresis
- 6: G    Shear rigidity
- 7: 2HG    Hysteresis at a shear angle of 0.5°
- 10    8: LC    Linearity of compression properties
- 9: WC    Compression energy
- 10: RC    Compression resilience
- 11: MIU    Mean coefficient of friction
- 12: MMD    Mean deviation of coefficient of friction
- 15    13: SMD    Mean deviation of surface roughness
- 14: T    Thickness at a pressure of 0.5 Kgf/cm
- 15: W    Weight per unit area

The equation to be used in the calculation is as follows:

$$G\text{-soft} = C_0 + \sum_{j=1}^{15} C_j \cdot (X_j - X_j (AV)) / \delta_j \quad (1)$$

Here,  $C_0$  is a constant (=6.253), and  $C_j$ ,  $X_j (AV)$  and  $\delta_j$  are coefficients shown in Table 1.

(2) KEC electromagnetic wave shielding capacity evaluation test method:

This test was carried out based on "Science of Textile Consumption", Vol. 40, No. 2 (1999), pp. 100-108, Society of Science of Textile Consumption of Japan.

Example 1

5           Used were silver-plated nylon multifilament  
yarns ("X-static" manufactured by Sauquit) of a variety of  
deniers as conductive fibers, and cotton yarns of variety  
of counts. The two types of yarns were aligned and fed to  
10       in all the courses, to prepare knitted materials with a  
reversible structure comprising a surface layer made of a  
cotton yarn and a back layer made of a conductive fiber  
yarn, the two layers being integrally laminated.

          Using the knitted materials, undergarments were  
15       sewn which had the cotton yarn knit layer on the inside  
and the conductive fiber knit layer on the outside.

          Fig. 1 shows the components and performance  
evaluation results (hand evaluation value of the knitted  
materials: G-soft; electromagnetic wave shielding  
20       capability (dB) measured by KEC method at 800 MHz). The  
figure reveals that the reversible knitted materials with  
a 24.5 gauge plain knit structure had a necessary  
electromagnetic wave shielding capability (20 dB)  
regardless of the count of the cotton yarn used, when a  
25       conductive fiber yarn having a denier of at least 100d/34f

was used. The denier of the conductive fiber yarn greatly influences the electromagnetic wave shielding capability.

On the other hand, as shown in Fig. 2, the knitted materials had satisfactory hand for practical use  
5 regardless of the denier of the conductive fiber yarn, but the count of the cotton yarn influenced the hand of the knitted materials. Specifically, the greater the cotton count was, the softer the hand became.

Further, wearing tests of the trial products of  
10 the undergarments revealed that the trial products had good hand without problems for practical use, had sufficient sweat absorbency, and caused no metal allergy.

#### Example 2

Using the same conductive fiber yarns and cotton  
15 yarns as in Example 1, the knitting operation of Example 1 was repeated except that the knit structure was changed to 18.6 gauge rib knitting. Thus, the two types of yarns were aligned and fed to a rib knitting machine to carry out plating in all the courses, to prepare reversible  
20 knitted materials comprising a surface layer made of a cotton yarn and a back layer made of a conductive fiber yarn. Using this knitted materials, shirts (undergarments) for wearing tests were sewn in the same manner as in Example 1. Further, performance evaluation  
25 was carried out in the same manner as in Example 1.

Fig. 3 shows the evaluation results, which were similar to the evaluation results obtained in Example 1. Fig. 3 also reveals that, when the conductive fiber knit yarn layer is made by rib knitting, it is necessary to use  
5 a conductive fiber yarn of at least 70d/34f to achieve a required electromagnetic wave shielding capability (20 dB). Thus, the denier of the conductive fiber yarn required to obtain a necessary shielding capability in this Example is lower than in Example 1.

10 Other performance evaluation showed similar results to the results obtained in Example 1, as presented in Fig. 4.

With the above structure, electromagnetic wave shielding knitted materials according to the present  
15 invention have good KES hand evaluation value (G-Soft) of greater than 6 and a high sweat absorbency, and enables provision of always wearable knit undergarments that protect the human body from electromagnetic wave damage with high productivity.

20 Further, using the reversible knitted materials of the invention, garments can be prepared in which a conductive fiber is covered by a clothing fiber, so that the conductive fiber does not come into direct contact with the skin and causes no skin disorder owing to metal  
25 allergy.

Table 1

j=		Basic mechanical properties of fabric	Unit	Cj	Xj (AV)	6j
1	LT	Linearity of tension	Dimensionless	-0.4202	0.7756	0.0679
2	WT	Tensile energy per unit area	gf · cm/cm <sup>2</sup>	-0.0401	0.6808	0.2557
3	RT	Tensile resilience	%	-0.0443	1.5952	0.0639
4	B	Bending rigidity per unit length	gf · cm <sup>2</sup> /cm	-1.4418	-1.7851	0.3288
5	2HB	Hysteresis	gf · cm/cm	0.1699	-1.6590	0.3213
6	G	Shear rigidity	gf/cm · deg	0.0251	-0.4000	0.1276
7	2HG	Hysteresis at a shear angle of 0.5°	gf/cm	-0.1357	0.0444	0.1486
8	LC	Linearity of compression properties	Dimensionless	-0.0005	0.6337	0.0692
9	WC	Compression energy	gf · cm/cm <sup>2</sup>	0.5584	-0.9937	0.1526
10	RC	Compression resilience	%	0.3396	38.1224	5.6815
11	MIU	Mean coefficient of friction	Dimensionless	-0.2220	-0.5952	0.0861
12	MMD	Mean deviation of coefficient of friction	Dimensionless	-0.0867	-1.5999	0.2018
13	SMD	Mean deviation of surface roughness	μm	-0.1525	0.9280	0.1999
14	T	Thickness at a pressure of 0.5 Kgf/cm	Mm	-0.2283	0.0638	0.1361
15	W	Weight per unit area	mg/cm <sup>2</sup>	0.3016	17.3383	5.0040

Example 3

Used were a 200 d silver-plated nylon yarn ("X-  
STATIC" manufactured by SAUQUIT) as a conductive fiber  
yarn, a single-covered yarn comprising a 20 d polyurethane  
5 stuffing thread covered with a 30 d nylon thread as an  
elastic fiber yarn, and a No. 30 count cotton yarn as a  
natural fiber yarn. The yarns were knitted to prepare a  
reversible plain knitted material of the present invention,  
which comprised a surface side made of the silver-plated  
10 nylon yarn and the single-covered yarn interknitted at a  
ratio of 1:1 (the proportion of the single-covered yarn  
being 1/2) and a back side (the side that would come into  
contact with the skin) made of the cotton yarn. The  
obtained material was cut and sewn in a routine manner to  
15 obtain an undergarment. Fig. 6 shows the relation between  
electromagnetic wave shielding capability and cost of the  
undergarment. The electromagnetic wave shielding  
capability is expressed in a value relative to a reference  
sample, based on the magnetic field shielding ratio at 800  
20 MHz measured according to the KEC (Kansai Electronic  
Industry Development Center) method. The cost is also  
expressed in a value relative to the reference sample.  
The reference sample was an undergarment prepared in the  
same manner as above except that the surface side was made  
25 by interknitting the silver-plated nylon yarn and the



single-covered yarn at a ratio of 1:0 (the proportion of the single-covered yarn being 0).

#### Example 4

5 An undergarment was prepared by following the procedure of Example 3 except that the silver-plated nylon yarn and the single-covered yarn were interknitted at a ratio of 1:2 (the proportion of the single-covered yarn being  $2/3$ ). The results are shown in Fig. 6 in the same manner as the results of Example 3.

#### 10 (Comparative Example 1)

An undergarment was prepared by following the procedure of Example 3, except that the silver-plated nylon yarn and the single-covered yarn were interknitted at a ratio of 1:3 (the proportion of the single-covered yarn being  $3/4$ ). The results are shown in Fig. 6 in the same manner as the results of Example 3.

#### (Comparative Example 2)

20 An undergarment was prepared by following the procedure of Example 3, except that the silver-plated nylon yarn and the single-covered yarn were interknitted at a ratio of 1:4 (the proportion of the single-covered yarn being  $4/5$ ). The results are shown in Fig. 6 in the same manner as the results of Example 3.

25 The results obtained above reveal that the undergarment obtained in Example 3 (silver-plated nylon

yarn: single-covered yarn=1:1) has an equivalent electromagnetic wave shielding capability but costs 30% less, as compared with the reference sample (silver-plated nylon yarn: single-covered yarn=1:0). Although the

5 undergarment of Example 4 (silver-plated nylon yarn: single-covered yarn=1:2) has about 20% reduced electromagnetic wave shielding capability, this does not cause any problems in the case where moderate electromagnetic wave shielding capability is required.

10 Further, the undergarment of Example 4 realizes remarkable cost reduction (50%). The undergarments of Comparative Examples 1 and 2 have substantially no electromagnetic wave shielding capability, although they attain cost reduction.

15 Therefore, the present invention provides an electromagnetic wave shielding knitted material and undergarment that do not cause unpleasant feeling when worn, or skin disorder due to metal allergy. The material and undergarment realize significant cost

20 reduction because of reduction in conduct fiber amount, while maintaining the electromagnetic wave shielding capability.

The material and undergarment of the invention not only protect the human body from the influence of

25 electromagnetic waves, but also effectively prevent

electromagnetic waves from causing malfunction of a pacemaker or other medical devices implanted in the human body.

Table 2 shows the types of models and individual settings used in Example 5 and 6 and Comparative Example 3 to 5.

Table 2

Type of model	Individual setting
Example 5 (short-sleeved, round-necked undershirt)	<ul style="list-style-type: none"><li>• Has a linear neck portion</li><li>• Covers the whole circumference of the torso</li></ul>
Example 6 (short-sleeved, V-necked undershirt)	<ul style="list-style-type: none"><li>• Neck depth: 80 mm</li><li>• Covers the whole circumference of the torso</li></ul>
Comparative Example 3 (short-sleeved collard shirt)	<ul style="list-style-type: none"><li>• Width of the front overlapping portion: 30 mm; Gap in the overlapping portion: 5 mm; Spaces between buttons (for fastening the right and left sides of the front at the centerline of the overlapping portion): 80 mm (the first button is at 10 mm below the upper edge of the shirt)</li><li>• Except for the gap in overlapping portion, covers the whole circumference of the torso</li></ul>
Comparative Example 4 (sleeveless vest)	<ul style="list-style-type: none"><li>• No overlapping portion in the right and left sides of the front (gap: 5 mm)</li><li>• Except for the gap, covers the whole circumference of the torso</li></ul>
Comparative Example 5 (without shielding garment)	

(Example 5)

Used were a silver-plated nylon fiber yarn ("X-static" manufactured by SAUQUIT, 100 denier/34 filaments) as a conductive fiber yarn, an elastic fiber yarn (a  
5 single-covered yarn comprising a 20 d polyurethane thread as a stuffing thread covered with a 30 d nylon thread), and No. 80 count cotton yarn. These yarns are knitted to prepare a reversible plain knitted material which  
10 comprised a surface side made of the silver-plated nylon yarn and the single-covered yarn interknitted at a ratio of 1:1, and a back side (the side that would come into contact with the skin) made of the cotton yarn. The  
obtained material was cut and sewn in a routine manner to obtain a short-sleeved, round-necked undergarment. The  
15 undergarment had neck tapes and sleeve tapes made of the same knitted material and folded in such a manner that the cotton yarn layers of these tapes came to the side to be in contact with the skin. The tapes were sewn so that the  
silver-plated nylon-containing layers of these tapes came  
20 into contact with the surface side of the body of the undergarment.

The reversible plain knitted material was tested for electromagnetic wave shielding capability by the  
method (1) described above. The short-sleeved, round-  
25 necked undergarment was put on the dummy and then tested

for electromagnetic wave shielding capability as a garment by the above method (2). Table 3 shows the test results. Fig. 8 shows the result of electromagnetic field distribution analysis of a model of the short-sleeved round-necked undergarment carried out by the above method (3).

Table 3

	Electromagnetic wave shielding capability as a material		Electromagnetic wave shielding capability as a garment		
	Electric field shielding capability (dB)	Magnetic field shielding capability (dB)	Distance to the dummy		
			5 cm (dB)	10 cm (dB)	20 cm (dB)
Ex. 5	44	23	22	23	28
Ex. 6			16	18	21
Comp. Ex. 3	37	16	-1	1	8
Comp. Ex. 4	36	17	-2	-1	6

# 10 (Example 6)

Using the reversible plain knitted material obtained in Example 5, a short-sleeved, V-necked undergarment was prepared by following the procedure of Example 5 except that the shape of the neck was changed to V neck. The short-sleeved, V-necked undergarment was put on the dummy, and tested for electromagnetic wave

shielding capability as a garment. Table 3 shows the test results. Fig. 9 shows the result of electromagnetic field distribution analysis of a model of the short-sleeved V-necked undergarment carried out by the above method (3).

5 (Comparative Example 3)

A collared shirt type electromagnetic wave shielding garment (a cardiac pacemaker protection garment against cellular telephone radiation, manufactured by MHP council) was used which was made of a plain weave fabric comprising, as the warp and weft, a conductive fiber yarn ("X-age" manufactured by Kanebo Spinning Corporation) containing a silver-plated nylon fiber ("X-static" manufactured by SAUQUIT). The weave fabric was tested for electromagnetic wave shielding capability as a material by the above method (1). The collard shirt type electromagnetic wave shielding garment was put on the dummy, and tested for electromagnetic wave shielding capability as a garment by the above method (2). Table 3 shows the results. Fig. 10 shows the result of electromagnetic field distribution analysis of a model of the collard shirt type electromagnetic wave shielding garment carried out by the above method (3).

(Comparative Example 4)

A vest type electromagnetic wave shielding garment ("MG Vest" manufactured by Freesia) comprising a

mesh fabric comprising a silver-coated polyester fiber was used. The mesh fabric was tested for electromagnetic wave shielding capability as a material by the above method (1).

The vest type electromagnetic wave shielding garment was put on the dummy and tested for electromagnetic wave shielding capability as a garment by the above method (2).

Table 3 shows the test results. Fig. 11 shows the result of electromagnetic field distribution analysis of a model of the vest type electromagnetic wave shielding garment carried out by the above method (3).

(Comparative Example 5)

An electromagnetic field distribution analysis was carried out using the dummy without an electromagnetic wave shielding garment. Fig. 12 shows the result.

As is apparent from Table 3, the reversible plain knitted material obtained in Example 5 is similar (slightly superior) in electromagnetic wave shielding capability as a material, to the weave fabric of Comparative Example 3 and the mesh fabric of Comparative Example 4. On the other hand, the electromagnetic wave shielding capabilities as a garment achieved in Examples 5 and 6 are remarkably superior, demonstrating that the electromagnetic wave shielding garment of the present invention is properly designed and made by using the apparatus for measuring and evaluating electromagnetic

wave shielding capability as a garment.

Further, in the FDTD electromagnetic field distribution analysis results (Figs. 8 to 12), the colors at the chest portions of the short-sleeved round-necked undergarment model of Example 5 (Fig. 8) and the short-sleeved V-necked undergarment model of Example 6 (Fig. 9) are green, yellow and orange, indicating that these models securely shield electromagnetic waves.

In contrast, the colors at the chest portions of the collared shirt type electromagnetic wave shielding garment model of Comparative Example 3 (Fig. 10) and the vest type electromagnetic wave shielding garment model of Comparative Example 4 (Fig. 11) are orange and red, which are approximately similar to the colors of the chest portion of the dummy without an electromagnetic wave shielding garment in Comparative Example 5 (Fig. 12). Thus, the garments of Comparative Examples have substantially no shielding effect against electromagnetic waves. These results agree well with the above measurement results of the electromagnetic field shielding capability as a garment.

As discussed above, the electromagnetic wave shielding garment according to the present invention prevents the influence on the human body of electromagnetic waves caused by high-frequency



5

CLAIMS

1. A reversible electromagnetic wave shielding knitted material comprising a conductive fiber yarn as a surface side and a natural fiber yarn as a back side.

5           2. A material according to claim 1, which comprises a plain knitted structure or rib knitted structure obtained by plating the conductive fiber yarn and the natural fiber yarn in all the courses of the knitted material.

10           3. A material according to claim 1, wherein the conductive fiber yarn is a multifilament in which each filament comprises a nylon fiber, a polyester fiber, an acrylic fiber, a polypropylene fiber or like synthetic fiber having a denier (d) of about 2 to about 8, and a  
15 metal component applied to a surface of the synthetic fiber by sputtering, vacuum deposition, electroless plating or like method.

          4. A material according to claim 1, wherein the conductive fiber yarn is a fiber of polyacetylene or like  
20 conductive resin, or a fine wire of gold, silver, copper, stainless steel or like metal.

          5. A material according to claim 1, wherein the natural fiber yarn comprises a natural fiber, a natural fiber/rayon fiber mixed spun yarn, or a natural fiber/  
25 synthetic fiber mixed spun yarn.

6. A material according to claim 1, wherein the  
conductive fiber yarn is a silver-plated nylon yarn having  
a denier (d) of about 70 to about 210, and the natural  
fiber yarn is a cotton yarn having a count of 30 to 150,  
5 the material having a KES hand value (G-soft) of at least  
6 and an electromagnetic wave shielding capability of at  
least 20 dB.

7. A material according to claim 1, which  
comprises, as the surface side, the conductive fiber yarn  
10 and an elastic fiber yarn interknitted with each other.

8. A material according to claim 7, wherein the  
elastic fiber yarn is a single-covered yarn or a double-  
covered yarn comprising a polyurethane thread as a  
stuffing thread covered with a nylon thread.

15 9. A material according to claim 7, wherein the  
elastic fiber yarn has a denier (d) of about 10 to about  
200.

10. A material according to claim 7, wherein  
the proportion of the elastic fiber yarn is greater than 0  
20 but not greater than 2/3 of the total amount of the  
conductive fiber yarn and the elastic fiber yarn  
interknitted with each other.

11. A material according to claim 1, which is  
used as an undergarment.

25 12. An electromagnetic wave shielding garment

obtainable by: measuring electromagnetic wave shielding capability as a garment using an apparatus for measuring and evaluating electromagnetic wave shielding capability comprising a measurement system in the shape of the upper  
5 part of the human body for measuring electromagnetic wave shielding capability as a garment in the state of being worn by the human body; designing a garment shape to obtain a desired electromagnetic wave shielding capability; and making a garment of the designed shape.

- 10 13. An electromagnetic wave shielding garment according to claim 12, wherein the apparatus for measuring and evaluating electromagnetic wave shielding capability comprises: a signal transmitter for emitting a high-frequency signal; a transmission antenna connected to the  
15 high-frequency signal transmitter for radiating a high-frequency electromagnetic field into a free space; a dummy which is similar to the human body in shape and electric constants including dielectric constant and magnetic permeability; a receiving antenna provided at a  
20 predetermined position within the dummy for receiving the high-frequency electromagnetic field, the receiving antenna being equivalent in impedance to the human body and similar in shape to a lead wire of a device surgically implantable in the human body; and a signal receiver  
25 connected to the receiving antenna for receiving the high-

frequency signal.

14. A garment according to claim 12, which has an electromagnetic wave shielding capability as a garment of at least 15 dB when the distance between the

5 transmission antenna and the surface of the dummy is 5 cm, at least 18 dB when the distance is 10 cm, and at least 20 dB when the distance is 20 cm, relative to the amount of electromagnetic waves received by the dummy without the garment.

10 15. An electromagnetic wave shielding garment according to claim 12, which has such a shape that forms no gap when worn.

16. An electromagnetic wave shielding garment according to claim 15, wherein the shape that forms no gap  
15 is an undergarment or a T-shirt.

17. An electromagnetic wave shielding garment according to claim 12, which prevents electromagnetic waves from causing cardiac pacemaker malfunction.

1/6

Fig. 1

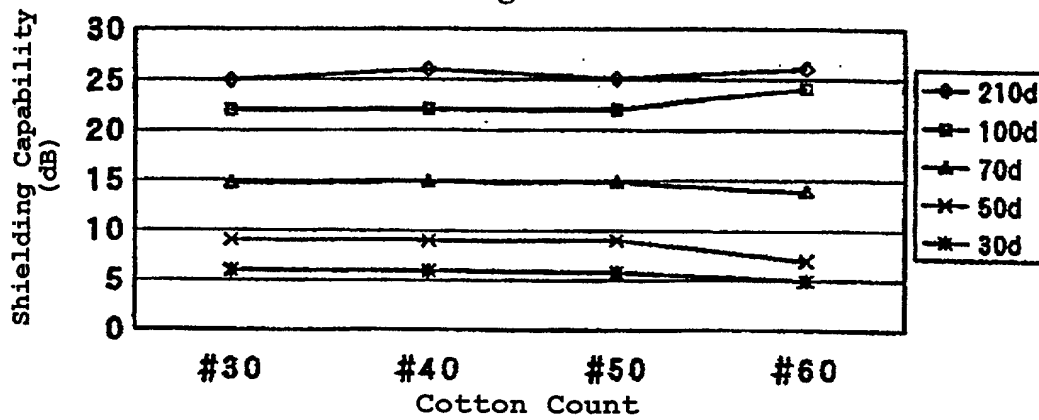


Fig. 2

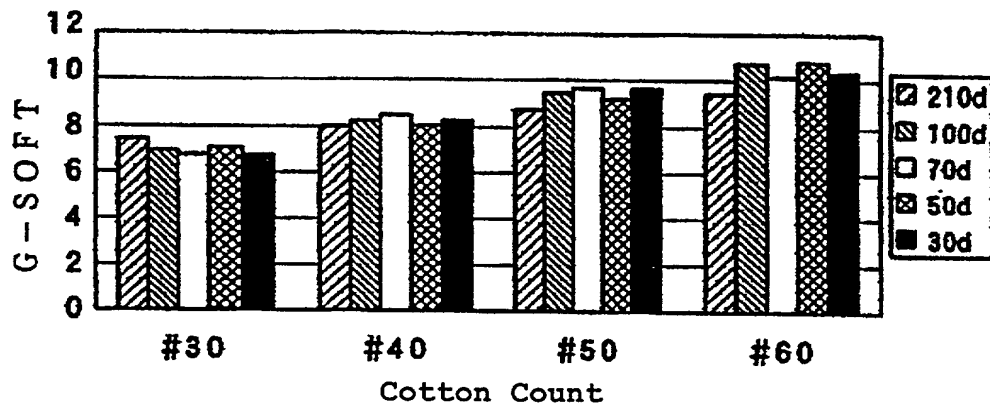
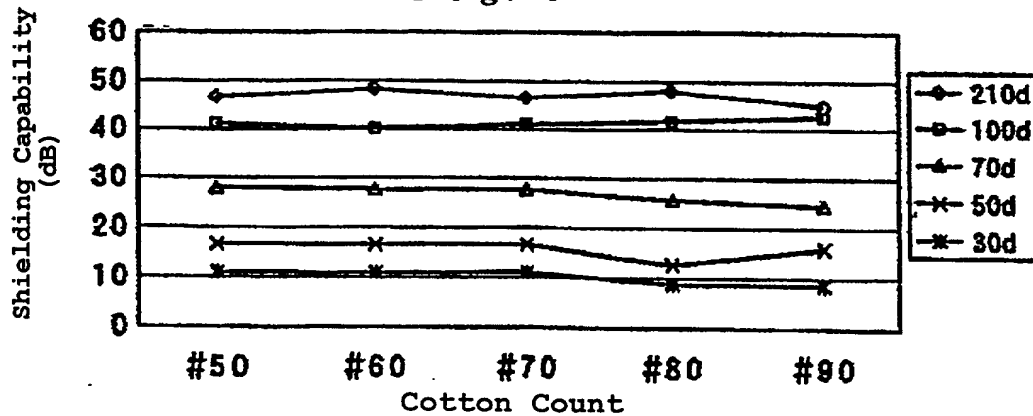


Fig. 3



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Fig. 4

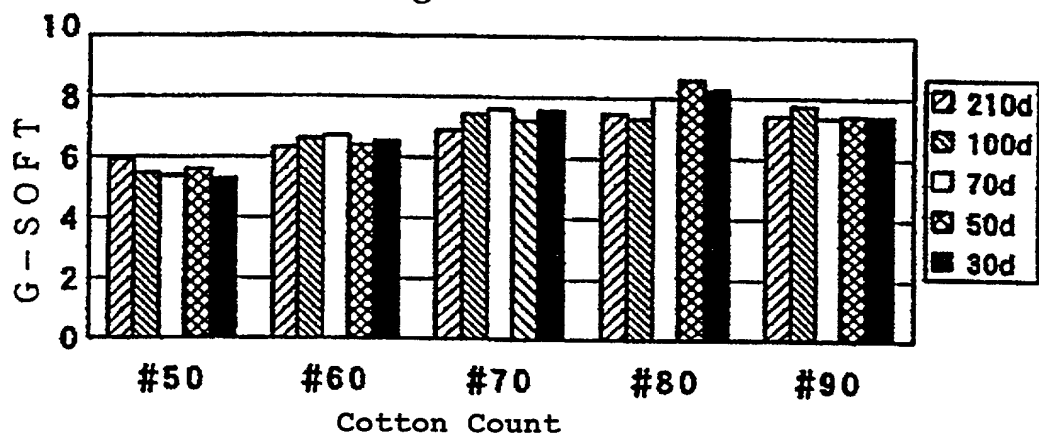
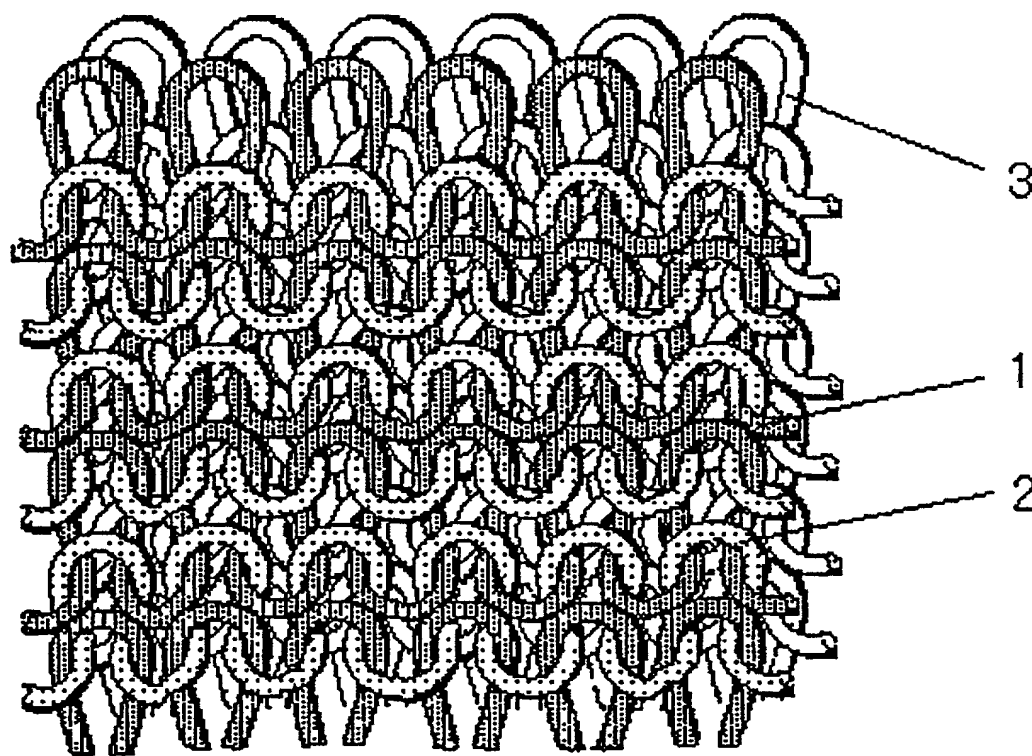


Fig. 5



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Fig. 6

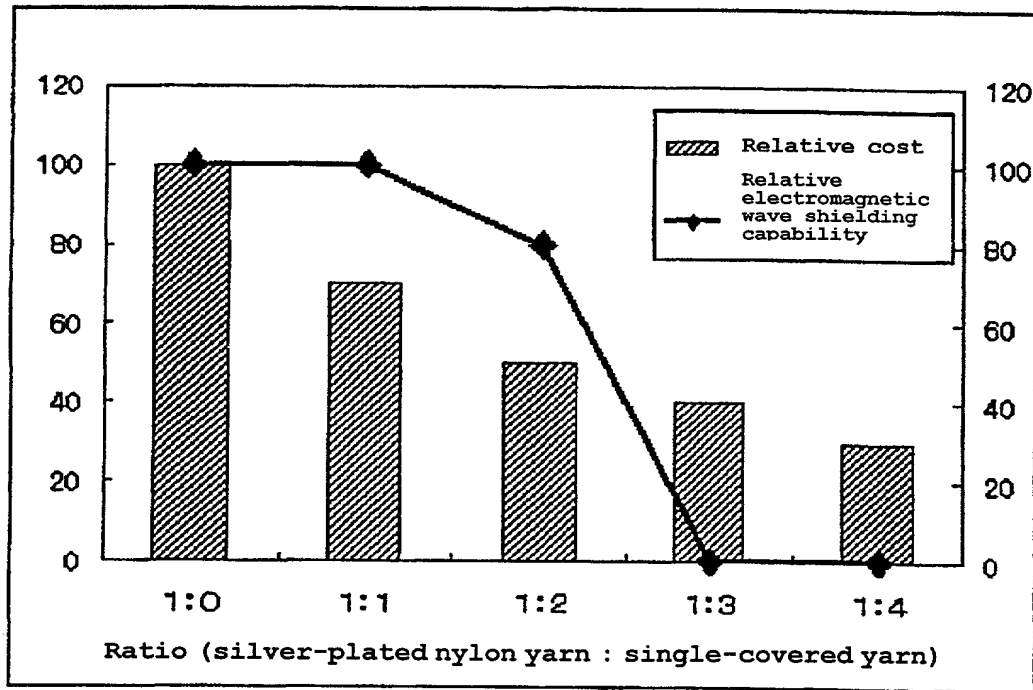
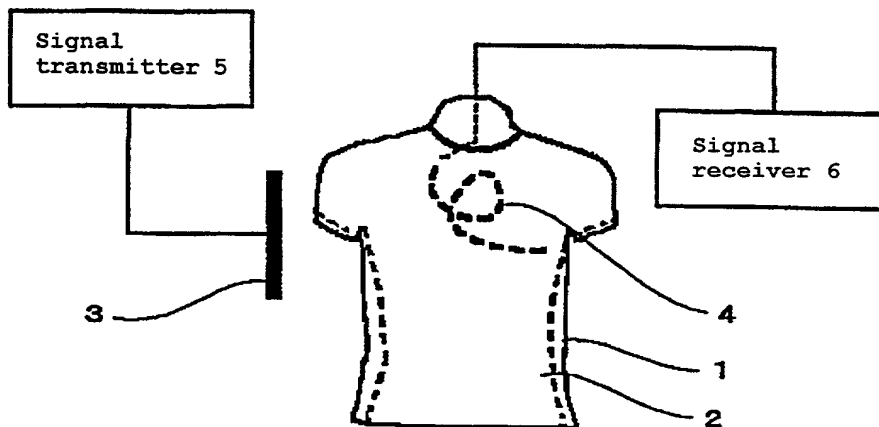


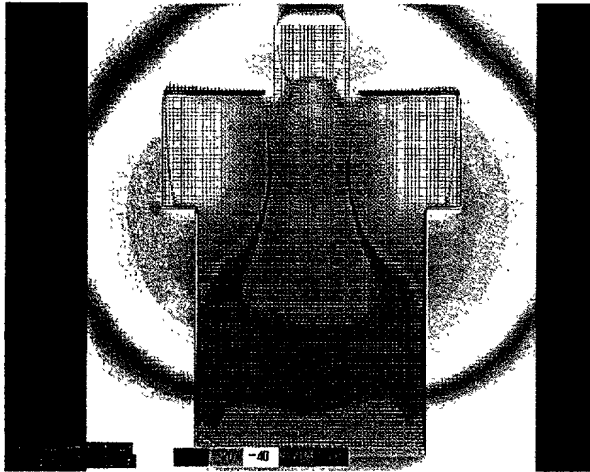
Fig. 7



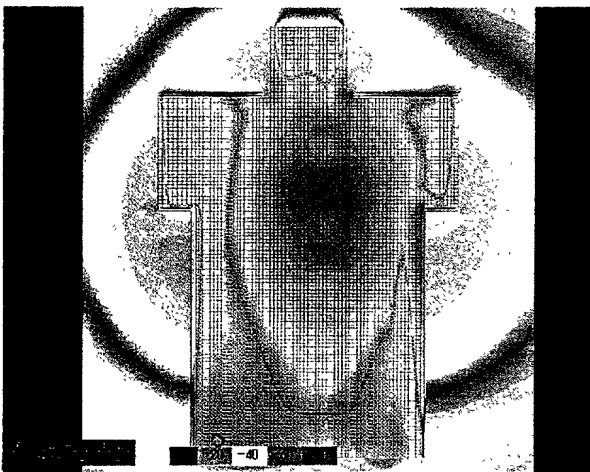


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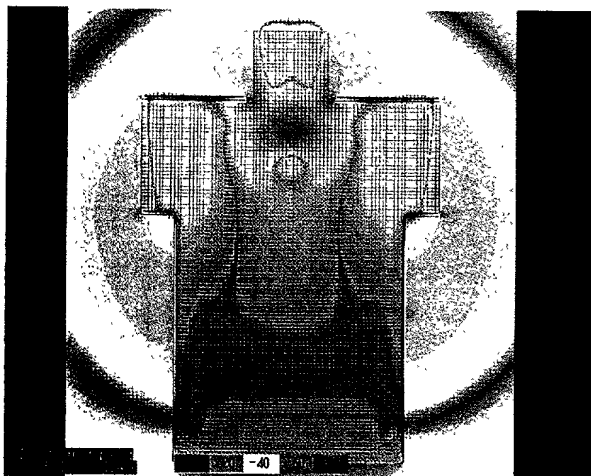


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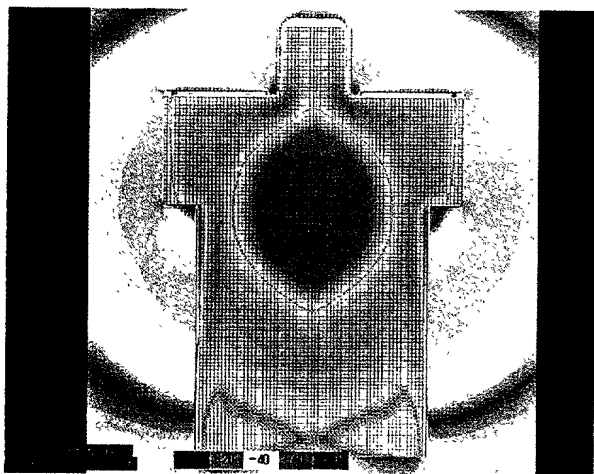


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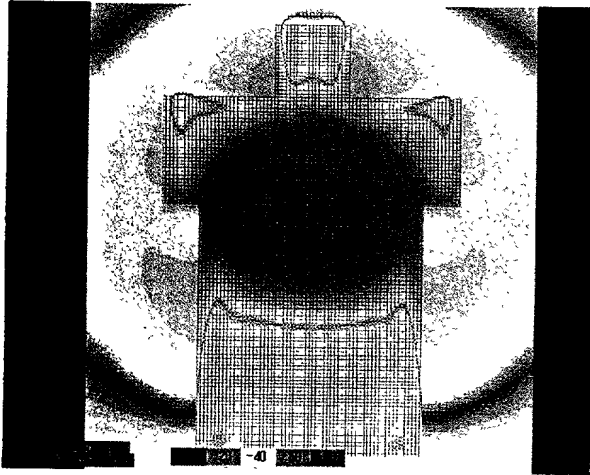
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**DECLARATION AND POWER OF ATTORNEY - USA PATENT APPLICATION**

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name;

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is

sought on the invention entitled ELECTROMAGNETIC WAVE SHIELDING KNITTED MATERIAL AND  
ELECTROMAGNETIC WAVE SHIELDING GARMENT

the specification of which:

- (a) is attached hereto; or
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No. \_\_\_\_\_ or Express Mail No., as Application No. not  
yet known \_\_\_\_\_ and was amended  
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and as amended under PCT Article 19 on \_\_\_\_\_  
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I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above;

I acknowledge the duty to disclose information which is material to the patentability of this application in accordance with Title 37, Code of Federal Regulations, § 1.56;

I hereby claim foreign priority benefits under Title 35, United States Code, § 119 of any foreign application(s) for patent, design or inventor's certificate or any PCT international application(s) listed below and have also identified below any foreign application(s) for patent, design or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed for the same subject matter having a filing date before that of the application(s) of which priority is claimed:

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COUNTRY (OR INDICATE IF PCT)	APPLICATION NUMBER	DATE OF FILING (day, month, year)	PRIORITY CLAIMED UNDER 37 U.S.C. § 119	
Japan	1999-144143	24/05/1999	X YES	NO
Japan	1999-144445	25/05/1999	X YES	NO
Japan	1999-311805	02/11/1999	X YES	NO
			YES	NO

I hereby claim the benefit under Title 35, United States Code, § 120 of any United States application(s) listed below, and insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code § 112, I acknowledge the duty to disclose to the U.S. Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56, which became available between the filing date of the prior application and the national or PCT international filing date of this application:

Prior U.S.A. Application(s)

Application No.: \_\_\_\_\_ Filing Date: \_\_\_\_\_ Status: \_\_\_\_\_

POWER OF ATTORNEY: I hereby appoint the registrants of Knobbe, Martens, Olson & Bear, LLP, 620 Newport Center Drive, Sixteenth Floor, Newport Beach, California 92660, Telephone (949) 760-0404, Customer No. 20,995.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful, false statements may jeopardize the validity of the application or any patent issued thereon.

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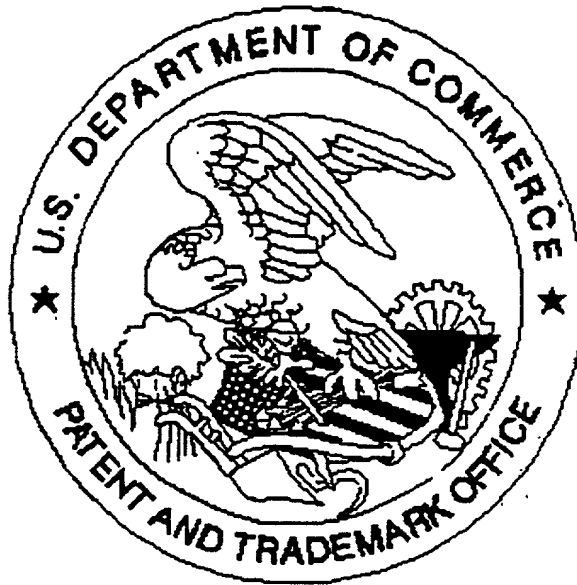
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